

which minimizes the Akaike Information Criterion. (See the COINT entry in Hall, 1995, TSP Reference Manual). The cointegration determination is conventionally made based on a .05 probability of error in rejecting the null hypothesis that the residuals contain a unit root, i.e., are nonstationary, which is evidence that the inferences are not reliable concerning either the t-statistics or the sum of squared residuals of the specification. For equation 4.1, with dependent variable CPT, analyzed in Table A-7, it cannot be concluded that any of the specifications are free of unit roots based on this criterion. For equation 4.2, with dependent variable CPDIFF, analyzed in Table A-8, only one specification is free of a unit root: the specification for D92. That for D93 also nearly rejects the unit root hypothesis. (The results for these specifications are shown in boldface type.) For equation 4.3, with dependent variable NPT, analyzed in Table A-9, no specification is free of a unit root. For equation 4.4, with dependent variable NPDIFF, analyzed in Table A-10, only the specification for D93 is free of a unit root, while that for D90 nearly rejects the unit root hypothesis.

The specifications on which Fuss bases his conclusions, those including F84 and D90, and D84 and F90, have comparatively high probabilities of unit roots in every case. Further, the test statistics for the two specifications are identical for each of the four equations tested. This result suggests that either (a) Fuss was unaware that the specifications carried no independent information, or that (b) the repetition of the evidence was intended to bolster his case.

b. Conclusions about reliability of the Fuss results

The evidence from the time series analysis of his statistical argument leads us to conclude that the Fuss results are not reliable. It is probable that a difficulty with the specifications he tested is that there are omitted variables from the specifications that systematically affect the dependent variables.

As noted above, the data used by Fuss is suspect. The Moody public utility bond rates cannot be verified as that used by Christensen. The time series of price changes for telephone inputs come from different sources with potentially disparate methods underlying them. The national economy input price index prior to 1984 comes from undocumented sources. After 1984, the national input price index is from the wrong sector (total private business rather than nonfarm business.)

In summary, the equations that Fuss estimates are, by standard statistical criteria, inappropriate for their intended use: inference about the shift in the input price differential. The data are undocumented or inapposite. The results Fuss obtained, therefore, contribute nothing to our understanding of the input price differential. *We conclude that his contention that the input price differential observed in the post-divestiture period is an aberration is not supported by his statistical analysis.*

6. How should the Input Price Differential be measured?

Two approaches have been put forward for measuring the input prices for the LECs in the context of TFP measurement for price cap regulation. The USTA (Christensen) approach is incorporated in the Simplified Christensen Model for measuring TFP. The AT&T recommendation for measuring

LEC input prices is put forward in the Performance-Based Model. Table 3 below shows a comparison of how the two approaches measure the prices of the major input categories.

Table 3
Procedures Used for Measuring LEC Input Prices

<u>Input Category</u>	<u>Performance-Based Model</u>	<u>Simplified Christensen Model</u>
Capital	Implicit cost of capital of the LECs measured as property income per unit of net capital stock, based on ARMIS data. Price of capital input is determined from short-term return on perpetual inventory capital stock.	Implicit cost of capital for U.S. economy, based on National Income and Product Accounts, Bureau of Economic Analysis. (Note: this is the capital cost component of the GDP-PI.)
Labor	Compensation per worker, based on ARMIS.	Compensation per worker, based on ARMIS.
Materials	Price index based on purchases of goods and services by telecommunications industry, computed from BLS Input-Output Study.	GDP-PI for total private business sector (<u>not</u> private nonfarm business sector), based on BLS data.

The entries in the above table make it clear that two of the three components of the Christensen price indices entering the aggregate input price are closely related to the GDP-PI. The materials price index is defined identically as the GDP-PI, while the capital input price is derived from an index that itself constitutes about 30 percent of the GDP-PI. Thus, in the Christensen model, more than two-thirds of the input price index is taken directly from the GDP-PI. It should not be surprising that a price index so constructed would track the GDP-PI rather closely. The concern of those analyzing the Christensen model is whether the choices of input prices made by that model are sensible in light of the alternatives, and whether there are more economically sound measures for materials and capital inputs. It would clearly be possible for Christensen to use the published LEC data for computing the capital inputs and the actual rates of return earned in the LECs. That Christensen chooses not to do so, but instead uses for a proxy the capital input price for the U.S. economy, as noted above, is surprising. Christensen in effect chooses data that are far less relevant than those which are relevant and immediately available.

The appropriate procedures used to measure the input price differential, using LEC input price data derived from the Performance-Based Model, have been described in the previously submitted Statement of Dr. Norsworthy (see Appendix A to the AT&T Comments at pages 17-21). These input price differential results have been updated to reflect recently released input price data from the Bureau of Labor Statistics concerning the input prices for the nonfarm business sector of the U.S. economy.

Table 4 below shows the movements in the labor, material and capital price indices for all RBOCs for the period 1985-1994. Also shown are the input price indices for the nonfarm private business sector and the RBOCs. The average rate of growth for input prices in the nonfarm business sector of the national economy is 3.01 percent per year for 1985-1994. The average rate of growth for input prices at the LECs is 0.22 percent per year for 1985-1994. And the best estimate of the input price differential for 1985-1994 is 2.79 percent per year.

Table 4. Input Price Indices for RBOCs

	ALL INPUTS NON-FARM BUSINESS 1985 = 1.000	LABOR ALL RBOCs 1985 = 1.000	MATERIALS ALL RBOCs 1985 = 1.000	CAPITAL ALL RBOCs 1985 = 1.000	ALL INPUTS ALL RBOCs 1985 = 1.000
1985	1.000	1.000	1.000	1.000	1.000
1986	1.030	1.025	1.021	1.101	1.051
1987	1.056	1.036	1.035	1.051	1.040
1988	1.096	1.064	1.059	0.837	0.974
1989	1.130	1.071	1.099	0.806	0.978
1990	1.168	1.158	1.143	0.598	0.934
1991	1.192	1.216	1.169	0.566	0.944
1992	1.228	1.223	1.194	0.583	0.962
1993	1.271	1.333	1.206	0.653	1.020
1994	1.310	1.373	1.234	0.610	1.020
Growth for Period	3.01%	3.52%	2.34%	-5.48%	0.22%
Sources: Rate of growth for Nonfarm Business Sector from Bureau of Labor Statistics RBOC input data computed in Performance-Based Model from BOC reports to FCC.					

C. Measurement of TFP for Interstate Access Services of the LECs

1. Background

The demand for interstate access to the LECs' local loops has grown much faster on average than demand for local services and intrastate access. This fact is widely acknowledged, and in the presence of economies of density leads to the conclusion that TFP in interstate services has grown substantially faster than company-wide (regulated) TFP. The question is whether there is a basis for a separate measure of TFP to be used as part of the X-Factor for calculating the price cap for interstate access services. In the Performance-Based Model, an AT&T in its response to the Fourth Δ FNPRM, Docket 94-1, an intentionally conservative measure of TFP for interstate access services was presented, with the associated X-Factor. The Simplified Christensen Model does not compute a separate interstate TFP, and proposes that company-wide TFP be used for the interstate access price cap. About 75% of the company-wide measure of TFP, based on revenues, measures efficiency in services not regulated by the FCC: intrastate and local services. This Section details the basis for the interstate TFP measure, and demonstrates that the interstate TFP growth measure in the Performance-Based Model is a lower bound on interstate TFP growth. In that model, TFP is calculated on the assumption that inputs used in the provision of interstate access services grow at the same rate as inputs for all LEC regulated services.

It should be noted that the objective is to establish *a plausible upper bound* on the growth of interstate inputs. If growth in interstate inputs is no greater than the growth in all inputs used in producing regulated services, then the ratio of interstate output growth to interstate input growth is a *lower bound* in interstate TFP growth. That lower bound is then appropriate for

use as the TFP measure in the X-Factor for the price cap for LEC interstate access charges.

The growth in the aggregate interstate output index is not subject to serious question, in that it is formed from the Fisher Ideal Index procedure, which is demonstrably superior to the Tornquist Index applied in the Initial and Simplified Christensen Models, and it includes interstate access minutes, end user lines, and special access lines.⁵ The aggregation procedure uses cost -based weights rather than revenue-based weights. Cost-based weights are closer to the requirements of economic theory than the revenue weights used in the Simplified Christensen Model. However, revenue weights are used (necessarily because of the absence of data to construct cost-based weights) in the aggregation of interstate services with other LEC regulated services to form total company TFP. The analytical basis for the argument is outlined first, to show what propositions must be established to conclude that interstate TFP, as we have measured it, is a lower bound appropriate for use in the price cap for interstate access charges by the LECs.

First note that, as argued by Christensen⁶ and as found in the work of other investigators, when traffic expands on the telephone network of the LECs, the local loop grows faster than the network itself, and thus there may be **substantial economies of density**. Such economies are found in econometric studies by Shin and Ying (1992, 1993), by Bellcore (1987) and by Norsworthy et al (1993). Hence, faster growth in interstate access volume than in access lines

⁵ The procedures applied in calculating the aggregate of interstate services is documented in the spreadsheet (inrv4FCC.wk3) supplied to the FCC. The construction of the company-wide aggregate of all LEC regulated services is documented in the spreadsheet (tfp4FCC.wk3) also supplied. The rationale for those procedures is explained in Appendices A and B to Comments of AT&T, Docket 94-1, January 16, 1996.

⁶ Christensen, California PUC Prepared Testimony, Sept. 1995.

in the local loop implies that total company TFP, $\Delta Y_A / \Delta X_A$, where A denotes all services provided by the company, increases the realization of **economies of density**. See Denny, Fuss & Waverman (1981). Economies (or diseconomies) of density are a type of **economies of scale** that result from the decrease (or increase) in unit cost of service that results from **more intensive use of an existing capital facility**. Economies (or diseconomies) of size, by contrast, are associated with the decrease (or increase) in the unit cost of service that results from **expansion of the capital facility**, while holding constant the intensity of use, or traffic carried by the facility.

Economies of scale, defined for a network-based industry or enterprise, occur when unit cost declines as the result of increasing the size of the network and the traffic carried by the network in the same proportion. In an industry such as telephone service that is characterized by important network facilities, economies of scale will be determined by both economies of density and economies of size as defined here. The econometric studies cited above find economies of density, but approximately constant returns to scale in the telephone industry. Thus, the increases in interstate access services on the network contribute positively to the LECs' TFP growth, just as Christensen argues the case of intrastate traffic.⁷

Next, note that marginal costs (or cost elasticities) from econometric estimates of cost allocation for the major categories of output, which would be ideal for use in the output aggregation for TFP measurement, are presently infeasible because of the instability of econometric model results, arising from the fact that there are many complex factors that must

⁷ Christensen, California PUC Prepared Testimony, Sept. 1995.

be included in the model and/or adjusted for in the data input. Consequently, at present econometric estimation cannot provide marginal cost or cost elasticity estimates for the interstate and other categories of regulated services, nor can it provide a basis for directly assessing separability of the underlying production process.⁸ Therefore we look for evidence elsewhere to establish the reasonableness of a separate TFP measure for interstate access services provided by the LECs.

We begin with the definition of TFP growth, which expresses the growth in TFP as the growth in a ratio of aggregate output, Y_C to aggregate input, X_C .

$$(1) \Delta TFP_{All\ Services} = \Delta \left(\frac{Y_C}{X_C} \right)$$

Aggregate output combines interstate access output, Y_A , (nonlocal) intrastate output, Y_T , and local output, Y_L . Aggregate input combines labor input, X_L , materials input, X_M , and capital input, X_K . Hence

$$(2) \Delta TFP_{All\ Services} = \Delta \left(\frac{Y_C}{X_C} \right) = \left(\frac{\Delta Y_C}{\Delta X_C} \right) = \frac{rw_A \cdot \Delta Y_A + rw_T \cdot \Delta Y_T + rw_L \cdot \Delta Y_L}{cw_L \cdot \Delta X_L + cw_M \cdot \Delta X_M + cw_K \cdot \Delta X_K}$$

where rw_A , rw_T and rw_L denote the revenue weights for interstate, intrastate and local outputs, respectively. Similarly, cw_L , cw_M and cw_K denote the cost weights for labor, materials and capital inputs, respectively.⁹

⁸ Even if separability of the underlying function is rejected, the distortion introduced by imposing or assuming separability of the function may not be quantitatively important. This issue is empirical, rather than logical.

⁹ Note that as expressed in these weights, the TFP expressions are exact for the Fisher Ideal Index used in the Performance Based-Model and for the Tornquist Index used in the Simplified Christensen Model. The computation of the weights is different for the two

(continued...)

To compute a separate measure of TFP for interstate services, equation (2) is modified as follows:

$$(3) \Delta TFP_{All\ Services} = \frac{rw_A \cdot \Delta Y_A + rw_O \cdot \Delta Y_O}{\Delta X_C} = rw_A \cdot \frac{\Delta Y_A}{\Delta X_C} + rw_O \cdot \frac{\Delta Y_O}{\Delta X_C}$$

where rw_O is the sum of the weights for intrastate and local services, and Y_O is the revenue weighted aggregate of the quantities of intrastate and local services. This manipulation is *algebraically* valid, but the separation of the expression for

ΔTFP_A , $\left(\frac{\Delta Y_A}{\Delta X_C} \right)$, from for other services, ΔTFP_O , entails the assumption that input

growth in production of interstate access services is the same as that for other services.

We seek an *upper bound* on growth in interstate TFP, that is, an estimate

$\Delta TFP_A^{est} \leq \Delta TFP_A$ where ΔTFP_A is the “true” rate of interstate TFP growth.

The empirical case for a separate measure of interstate access begins with the evidence that interstate services have grown more rapidly than other services, and is supplemented with empirical evidence from the jurisdictional separations data, as reported to the Commission.

⁹ (...continued)

indices, although they are quantitatively similar when the prices and quantities are the same and not close to zero. The Tornquist Index breaks down (i.e. is seriously distorted) for prices or quantities very close to zero, and is undefined when a price or quantity is zero.

The interpretation of the latter depends on understanding some elements of the history of the allocation of costs to interstate access. A sketch of those elements is also provided.

2. Interstate Services Have Grown Faster Than Other Regulated LEC Services

Interstate access services provided by the LECs have grown more rapidly than local service or intrastate toll service. Table 5 shows rates of growth for three categories of telephone service in the 1985-1994 period. The three broad categories of LEC service are priced differently, sold to different customers, and/or regulated by different authorities, pointed out argued in Appendix A to AT&T's Comments. There are two important consequences of this more rapid growth: company TFP has grown more rapidly than it would if interstate outputs grew at the same rate as intrastate and local outputs combined, and consequently there has been an increasing subsidy from interstate service to other services (local/intrastate) provided by the LECs. Both of these propositions and their implications are explored below.

**Table 5: Rates of Growth of Telephone Services
ALL RBOCs, 1985-1994**

Year	Fisher Ideal Quantity Index: Interstate Access	Local Service: Number of Calls	Intrastate Toll: Minutes of Use	Fisher Ideal Quantity Index: All Services
1985	1.000	1.000	1.000	1.000
1986	1.070	1.012	1.037	1.033
1987	1.152	1.019	1.094	1.071
1988	1.258	1.067	1.166	1.139
1989	1.374	1.105	1.267	1.289
1990	1.489	1.146	1.399	1.350
1991	1.573	1.182	1.500	1.278
1992	1.651	1.223	1.552	1.402
1993	1.741	1.262	1.683	1.470
1994	1.849	1.314	1.840	1.555
Growth for Period	6.83%	3.03%	6.78%	4.90%
Average Revenue Weight for Period in Total Company TFP	0.2573	0.5077	0.2351	1.0000

1985 = 1.000

Source: Computed in Performance-Based TFP Model from data in BOC reports to FCC

3. Background on the jurisdictional separations process

At this point, it is useful to review briefly some of the developments in the jurisdictional separations process used by the Commission to allocate costs associated with commonly used plant between the interstate and intrastate jurisdictions.

The principal type of commonly used plant used by the LECs to provide interstate access service is the "local loop" or "subscriber loop", which is the line from the customer's premises to the LEC's central office. These facilities, and their related costs, are classified in the separations jargon as non-traffic sensitive" (NTS) costs, in that they do not vary with the volume of traffic (i.e., they are basically fixed). As the Commission and the courts have recognized, these NTS costs give rise to economies of density as interstate access traffic on the local loop increases, and therefore to economies of scale. From an economic point of view, the marginal cost of interstate use is minimal, because the "local companies' NTS costs do not increase as a result of interstate use."¹⁰

Since the 1970's, the separations procedures have been designed to allocate a disproportionately large amount of the NTS costs to the interstate jurisdiction. Initially, the procedure for assigning NTS costs involved measuring the relative use of the common plant and applying that measure to assign costs to each jurisdiction. In 1970, the FCC adopted the Ozark Plan, which dramatically increased NTS cost allocations to the interstate jurisdiction. Under that Plan, NTS costs were assigned to interstate at approximately 3.3 times the proportion of

¹⁰ Rural Tel. Coalition v. FCC, 838 F.2d 1307, 1311 (D.C. Cir. 1988).

interstate use. This calculation was referred to as the "subscriber plant factor," or "SPF."¹¹

Note that this allocation procedure fails to take into account economies of density.

In the ensuing years, more and more NTS costs were allocated to interstate services. The relative portion of interstate use, compared to intrastate use, increased each year, and the operation of SPF greatly magnified the interstate allocation of costs. As the proportion of interstate use increased, the SPF caused NTS costs assigned interstate to increase more than three times as fast.¹² Thus, the proportion of interstate use increased from 5.5 percent in 1972 to 8.3 percent in 1983, and with the effect of SPF the NTS costs assigned to interstate during that period increased by nearly 500 percent, from about \$1.9 billion to \$11.2 billion.¹³

In the early 1980's, this problem was considered by a Federal-State Joint Board, and upon its recommendation the Commission decided to "freeze" the amount of the NTS costs allocated to interstate at twenty-five percent.¹⁴ This frozen SPF approach commenced in 1986, but allowed for a transition period before it was fully implemented.

As these background facts indicate, the jurisdictional separations process has imposed a disproportionate level of costs on the interstate services. Yet even under these circumstances, costs allocated to interstate access have increased less than intrastate costs in absolute terms,

¹¹ Id.

¹² Id.

¹³ MCI v. FCC, 750 F.2d 135, 138 (D.C. Cir. 1980).

¹⁴ Rural Tel. Coalition, 838 F.2d at 1311.

and relative to total company revenue, as shown in the next section. The input costs applicable to the LECs' interstate access services would, of course, be much lower if they were assigned strictly on a relative use basis, and would be even lower than that if determined by marginal costs.

4. Evidence on input growth from cost allocations

Because economies of density are present, the greater growth of interstate services relative to other services provided by the LECs implies that interstate services have contributed more to TFP growth of the LECs than the growth of other services. Table 6 shows revenue and expenditure ratios for all Tier 1 price cap LECs. It is clear from that table that the cost share of interstate services in total expenditures is less than its corresponding revenue share. Even when the jurisdictional separation rules are applied, which as explained above, substantially overallocate costs to interstate services by design, the interstate cost share was only 68.9 percent of revenues for 1989-94, as Table 6 shows at Line (D). The corresponding ratio for all services was 74.1 percent, shown in Line (B). On a year-to-year basis, expenses as a share of revenues declined faster for interstate than for all services, *even though* the unit charge for interstate services was falling relative to the unit charge for all services (-4.28 percent per year vs. -2.94 percent per year).¹⁵ This unit revenue effect, which is a consequence of faster growth of interstate services than all services combined, is illustrated in Line (E) of the table. The average annual growth of expenditures allocated to all services was 1.6 percent faster than for expenditures allocated to interstate services, as is shown in Line (F). During the 1989

¹⁵ Computed from unit revenue data in Performance-Based Model. Growth rates are computed from Table 5.

to 1994 period, output for all services grew 3.75 percent per year, while output for interstate services grew 5.94 percent.¹⁶ In other words, interstate inputs were growing more slowly than were inputs for all regulated services provided by the LECs. Jurisdictional cost allocations, based on the sketch of their historical development given above, have been shown to be *liberal* in their assignment of cost increases to interstate services. Indeed, this evidence indicates that the difference between the growth of interstate and intrastate inputs seems to be stable or increasing. **Thus, it is concluded that the growth in all inputs is an upper bound on the growth in inputs for interstate services.**

¹⁶ Computed from unit revenue data in Performance-Based Model. Growth rates are computed from Table 5.

Table 6

All Tier 1 Price Cap LECs							
							Average
	1989	1990	1991	1992	1993	1994	1989-94
(A) Ratio of Interstate and IX revenue to total revenue subject to separations	25.17%	24.45%	24.08%	24.18%	24.18%	24.62%	24.45%
(B) Ratio of expenditure to revenue: all services	72.55%	72.82%	73.68%	74.05%	74.37%	77.20%	74.11
(C) Ratio of Interstate + IX expenditure to total expenditure subject to separations	23.98%	23.51%	22.97%	22.37%	21.97%	21.65%	22.74%
(D) Ratio of expenditure to revenue: Interstate and IX only	69.11%	70.00%	70.29%	68.51%	67.56%	67.88%	68.89%
(E) Ratio of (D) to (B)	95.26%	96.13%	95.40%	92.52%	90.85%	87.92%	93.01%
(F) Annual input saving: Interstate + IX compared to all services		0.91%	-0.77%	-3.06%	-1.82%	-3.27%	-1.60%
Data Source: ARMIS 4301 Available only for 1989 to 1994 as shown.							

Finally, to insure its reasonableness, it is useful to examine, on a heuristic basis, the proposition that inputs for interstate services grew no faster than inputs for all services by examining prices and quantities for each input category. Virtually all capital input used in interstate access services is shared with other services; if anything, the jurisdictional separations process outlined above overallocates capital input to interstate services by relying as it originally did on relative use by interstate and other services (and then later magnifying that use). However, the reverse is not true: there are capital inputs used in local and intrastate services that are not used by interstate access services. Consequently, the level of total capital input shared by interstate services is reasonably expected to be lower than total capital input. Examination of capital stocks for the price cap LECs in the 1985-1994 period shows more rapid growth in general support equipment – about **7.4 percent** – than in communication equipment and buildings – each about **2.5 percent** per year.¹⁷ The latter categories are likely to be more heavily used by interstate services than general support equipment, which includes, *inter alia*, motor vehicles and aircraft, as well as office furniture.

Materials input used in interstate services is likely to be predominantly physical goods related to maintenance of the capital equipment. Based on the BLS input-output model on which the materials price index is based, expenditures for purchased services, which include such inputs as business services, travel, advertising, etc., have grown more rapidly than expenditures on physical inputs in the telecommunications industry.

¹⁷ Christensen spreadsheet, Table 8.

Employment at the LECs has been declining over the 1985-1994 period at an annual rate of 3.4 percent.¹⁸ Clearly, labor input is used much more in the provision of other services and thus will have a lower cost weight in interstate services than in other services. The overall weight for labor input declined in total only about 2.5 percent, however, from 1985 to 1994 because the wage rate was rising more rapidly than prices of capital and materials inputs. Thus, while the effect of the labor input alone is to decrease inputs in other services more rapidly than in interstate services, the labor effect is likely to be overwhelmed by the capital and materials effects. Indeed, the evidence from the separations data shows an overall decline in interstate inputs relative to other inputs.

Summary

Based on the available data, it is entirely feasible to calculate a separate and bounded measure of TFP and the associated X-Factor for the LEC interstate access services and other regulated LEC telephone services, based on conservative assumptions about costs and direct measurement of outputs in those respective sectors, using only publicly available data. Moreover, the results of the calculations are conservative as a result of both the assumptions underlying the calculations. This conservative bias the evidence from the LECs' reports reflecting jurisdictional separations, as well as from the pattern of input expenditures in the input-output studies of the Bureau of Labor Statistics. Finally, when examined in heuristic terms, the observed results and their interpretation is plausible. Of course, if more specific data concerning the LECs' expenditures and prices of materials were reported, further improvements in estimates

¹⁸ Input output study of materials inputs supporting the Performance Based Model, provided 9 February 1996 to the commission and USTA. Performance Based Model spreadsheet.

of the input prices and the input price differential, as well as the associated TFP and X-Factors, could be achieved.

D. Comparison of Performance Based Model for TFP Measurement with Initial and Simplified Christensen Models.

This section compares the Performance Based Model (PBM) with the Initial and Simplified Christensen Models (ICM and SCM, respectively) developed for USTA. In AT&T's opening Comments, a detailed comparison of the PBM and ICM was presented. In the interim, several changes were made to the Initial Christensen Model, resulting in the Simplified Christensen Model. These models are summarized in terms of their characteristics in Table 7. That table also indicates changes in the models in italics.

In Appendix A to AT&T's Comments, (Fourth FNPRM) a detailed comparison of the PBM and the ICM was presented, as well as a critique of the ICM. Except where changes are indicated in Table 7, the shortcomings of the ICM continue in the SCM. The earlier criticisms are not repeated here, but apply with equal force. Therefore, we focus here only on the changes and their implications.

Table 7. Characteristics of Performance-Based Model and USTA's Initial and Simplified Christensen Models.

<u>Performance-Based Model</u>	<u>Initial Christensen Model</u>	<u>Simplified Christensen Model</u>
1. All costs are based on actual historical performance of the LEC.	1. Capital costs are <u>assumed</u> and do not reflect actual costs paid by customers.	1. Capital costs are <u>assumed</u> and do not reflect actual costs paid by customers.
2. Relies exclusively on publicly available data and fully documented methodology.	2. Uses some proprietary data not publicly available; procedures are not fully described.	2. <i>Uses publicly available data; procedures are still not fully described.</i>
3. Directly measures the input price differential.	3. Assumes that input price differential is zero.	3. Assumes that input price differential is zero.
4. Directly measures productivity for the LECs' interstate access services.	4. Measures only productivity for all LECs' services, and assumes that productivity measure applies to the LECs' interstate services.	4. Measures only productivity for all LECs' services, and assumes that productivity measure applies to the LECs' interstate services.
5. Actual utilization of capital at LECs is captured in TFP calculation. Allows for excess or deficient returns to capital input.	5. Utilization of capital assumed to be ideal at all times in TFP calculation. Makes no allowance for excess or deficient returns to capital input.	5. Utilization of capital assumed to be ideal at all times in TFP calculation. Makes no allowance for excess or deficient returns to capital input.
6. All costs assessed on ratepayers are used in TFP calculation.	6. Capital costs assigned to ratepayers may differ from capital costs used in TFP calculation.	6. Capital costs assigned to ratepayers may differ from capital costs used in TFP calculation.

- | | | |
|--|---|--|
| 7. Depreciation used in TFP calculation is that authorized by FCC for telecommunications plant and equipment. | 7. Depreciation used in TFP calculation differs from FCC authorized rates, and is not based on telecommunications industry. | 7. <i>Depreciation used in TFP calculation differs from FCC authorized rates, and is not based on telecommunications industry. Rates now come from the Bureau of Economic Analysis</i> |
| 8. Costs of capital are based on LECs' actual costs, with debt and equity costs separately measured. | 8. Costs of capital do not distinguish debt from equity, and are thus distorted by upward bias. | 8. <i>User costs of capital that now distinguishes debt from equity.</i> |
| 9. In earlier Performance Based Model, adjustment to capital stock for technological changes in performance of capital goods is included in the TFP calculation. | 9. No adjustment to capital stock is made for technological changes in performance of capital goods. ^a | 9. No adjustment to capital stock is made for technological changes in performance of capital goods. |
| 10. <i>Capital stock is computed by perpetual inventory method. Adjustment of stock for changes in quality no longer applied. <u>(Note that this change does not affect the X-Factor.)</u></i> | 10. Capital stock is computed by perpetual inventory method. | 10. Capital stock is computed by perpetual inventory method. |

1. Capital measurement in the Performance Based Model

In the crucial area of **capital measurement**, for example, the Performance-Based Model now uses a **real net capital stock** based on the **perpetual inventory method**. Initially, the PBM used the net book value as the measure of the capital stock. The treatment of depreciation still reflects

the regulatory accounting practices on which current and past reporting of the financial performance of the LECs is based. Depreciation rates in the PBM were computed from the depreciation reported for each of six asset classes for the 1988-1994 period. Use of these later years and omitting the data for 1985-1987 from the calculation eliminates the data problems associated with accounting revisions in 1988. It is important to note that the choice of depreciation rates in the PBM affects the measured TFP for the LECs to a degree that is exactly offset by simultaneous changes in the Input Price Differential, so that the X-Factor remains unchanged. This outcome is a consequence of the PBM's use of the actual cost of capital levied on ratepayers, rather than an assumed rate of return as used by both the ICM and the SCM. The same is true of the hedonic adjustment of capital input. Initially, the capital input in the PBM was adjusted by an econometrically estimated hedonic index based on the central office switching and interoffice transmission technologies deployed by the LECs. The adjustment was developed in the context of the net book value measure of the capital input. It captures not only the change in the productivity of the stock based on technological advances, but also adjusts for over- or under-deflation and over- or under-depreciation of the capital input. Hence the adjustment is not appropriate for direct use with the perpetual inventory measure of the capital input now used in the PBM. However, the perpetual inventory approach conforms better to conventional practice and to economic theory.

2. Revisions in the Simplified Christensen Model

The ICM has been modified in two key respects to become the SCM. First, the claim is made that the data employed in the SCM are now based on publicly available sources.¹⁹ Specifically, the depreciation rates in the SCM are from the Bureau of Economic Analysis.²⁰ In making these modifications, however, Christensen in its analysis of capital input still does not use the data available from the FCC to derive and use the actual rates of return realized by the LECs. This shortcoming remains a major obstacle to both the realism of the SCM and the credibility of its TFP results. Second, the SCM now recognizes the distinction between debt and equity in determining the user cost of capital, which is in turn the basis for aggregating the various capital assets into an index of capital input. This improvement results in elimination of one criticism that AT&T made of the ICM. As noted above, however, other serious problems remain.

3. Comparison of PBM and SCM with the TFP measurement methodologies of the Bureau of Labor Statistics.

In explaining the methodology applied in the SCM, Christensen compares its TFP methods to those used by the Bureau of Labor Statistics (BLS) in computing industry or sectoral level measures. Some of these comparative statements obscure important differences, however.

¹⁹ Subject to later verification, we accept that this assertion by USTA is true. However, it has developed that the parallel assertion made in the past about Christensen's methods in his analysis of the input price differential on behalf of USTA is not correct.

²⁰ We have not yet examined the development of those depreciation rates.

It is clear that Christensen's procedures differ sharply from those employed by the BLS in its sectoral productivity studies, while in fact the methods used in the Performance-Based Model are closer to the BLS.

- (1) BLS uses sector-specific property income measures to compute rates of return, as does the Performance-Based Model. That is, the actual revenues in the industry are used to measure the rate of return. In the BLS method, the total revenues of the industry is equal the total cost of production. Christensen use an economy-wide measure based on the economy-wide cost of capital. Consequently, total revenues diverge from total cost of production, not only in the short run, as might be occasioned by economic profits or losses, but over the long run as well. Christensen's procedures in previous studies have varied – it used Moody's public utility bond yield in its 1994 and 1995 FCC filings. What was done in its various Bell studies is unknown.
- (2) BLS uses input-output tables to form the basis of its intermediate input price and quantity series, as does the PBM. Christensen uses the gross domestic implicit price deflator, which does not match the target sector identified by the Commission for the interstate access price cap.
- (3) BLS uses the hyperbolic decay model for depreciation of capital in its industry and aggregate capital input measurement. Both Christensen and the PBM use the more